Urban Dispersion Field Experiments for Model Evaluation

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Objectives

The objective of this 5-year research project is to conduct atmospheric field studies to provide data for technically and operationally evaluating the dispersion models being developed within the Modeling and Prediction component of CBNP. A hierarchy of computer models is being developed covering transport distances ranging from dispersion around individual buildings (tens-of-meters), to dispersion through the urban area (hundreds-of-meters to a few kilometers), and dispersion beyond the urban area to the regional-scale (tens-of-kilometers to a hundred kilometers). To adequately evaluate the hierarchy of models, field studies will be conducted resolving all the transport scales concurrently so that the various models can be evaluated using the same meteorological conditions.

Several project elements will be completed to achieve the objective. The project elements are: 1) define technical and operational model evaluation standards, 2) define data needed to evaluate the hierarchy of dispersion models, 3) plan and design field measurement campaigns to fill the data needs, 4) coordinate multi-agency support (and participation) in field campaigns and conduct the campaigns, 5) provide field data to the modelers for model evaluation, and 6) analyze and publish the results from the field campaigns.

Recent Progress

Important progress was made this first year towards accomplishing the project objective. Close interactions with the CBNP modelers began where data needed to evaluate models were identified and simulations of the first field campaign in Salt Lake City, Utah were provided to help plan the experiments. A Field Experimental Design Working Group was formed from CBNP investigators (5) and external university/government researchers (5) to help guide the design of field experiments based on model evaluation standards, input data requirements of the models, available tracer and meteorological measurement systems, and budgetary limits.

A preliminary meteorological study was conducted in Salt Lake City, Utah during January 21 through April 12, 2000 where seven surface weather stations were deployed across Salt Lake City.

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The objective of this study was to determine local wintertime wind patterns in Salt Lake City in support of security planning for the 2002 Winter Olympics and to assist in the design of the October 2000 Salt Lake City field campaign. Analysis of the wind data shows a very definite diurnal wind pattern in Salt Lake City where the mesoscale meteorological effects (mountain-valley winds, slope winds, land-lake breeze) dominate the near-surface wind patterns especially under conditions of weak synoptic forcing (weather dominated by high pressure system). The winds through downtown Salt Lake City are typically from the southeast at night and from the northwest during the day.

The primary accomplishment this year was the design and execution of a major field campaign in Salt Lake City, Utah (see first two figures). Tracer/meteorological experiments were conducted during October 2000 that provide a unique set of night-time atmospheric dispersion data covering transport scales from individual buildings on through the urban-scale to the regional-scale. This research collaborated closely with DOE's Environmental Meteorology Program by adding building-scale through urban-scale experiments (URBAN1) to their regional-scale Vertical Transport and Mixing experiments (VTMX) in the greater Salt Lake City area. (Refer to web sites *www.pnl.gov/vtmx/* and *www.pnl.gov/atmos_sciences/Jdf/design.html* for VTMX details.)

Meteorological and tracer instrumentation were installed throughout the Salt Lake Basin for the month of October 2000 for the combined VTMX/URBAN1 field campaign. Instruments were sited to resolve scales-of-motion ranging from flows around individual buildings in downtown Salt Lake City to flows throughout the greater Salt Lake Basin. Six tracer experiments were conducted during October where two perfluorocarbon tracers (PFTs) were released from within the Salt Lake Basin (south of downtown Salt Lake City), and sulfur hexafluoride (SF_6) and two additional PFTs were released from two downtown Salt Lake City locations (see third figure). A total of five inert tracer gases (4 PFTs and SF_6) were released during nighttime hours (primarily between 2200 to 0600 MST) for release durations ranging from 3 h to 8 h depending on the tracer type and the release location. The six tracer experiments were conducted primarily during clear weather conditions where the wind patterns were governed by mesoscale meteorological processes.

Time-integrated tracer samples (nominally 5-minute to 2-hour integration times) were collected by 200 samplers located throughout the Salt Lake Basin. The sampling nominally extended from just before tracer release start (~2200 MST) through the night until the next afternoon (~1400 MST). The tracer samplers were distributed to resolve the various scales-of-motion being studied where 45 SF_6 samplers were located around the downtown study building, 40 SF_6/PFT samplers and 24 SF_6 samplers were located in a 5-block-square area (25 blocks) of downtown, 36 SF_6 samplers were located on three sampling arcs (2-, 4-, and 6-km) to the northwest of the downtown SF_6 release location, and 55 PFT samplers were located throughout the Salt Lake Basin. A total of nearly 11,000 SF_6 samples and 5,000 PFT samples were collected during the six tracer experiments.

In addition to the 200 time-integrated tracer samplers deployed during the combined VTMX/URBAN1 experiments, two multiplexed SF_6 analyzers were located around the downtown study building, three mobile fast-response SF_6 analyzers (1 Hz sampling rate) operated in the 25-block downtown study area, and three mobile SF_6 analyzers traversed the three sampling arcs to the northwest of downtown.

Numerous meteorological instruments were deployed throughout downtown Salt Lake City as part of URBAN1 and throughout the Salt Lake Basin as part of VTMX. The major instrumentation deployed during October 2000 included 29 surface weather stations (enhancing the existing network of 18 stations); 8 radar profilers and 10 acoustic sodars continuously measuring wind profiles; 4

rawinsonde free-release balloon systems periodically measuring profiles of wind and temperature during each experiment; 4 tethered-balloon systems periodically measuring wind and temperature profiles during each experiment; 54 temperature data loggers continuously measuring temperature near the surface throughout downtown and across the Salt Lake Basin; 33 sonic anemometers for measuring turbulence and flux profiles in the basin and for measuring turbulence characteristics around select buildings in downtown; and two doppler lidars for continuously mapping winds across the Salt Lake Basin and over downtown Salt Lake City during each experiment.

The October 2000 VTMX/URBAN1 field campaign in Salt Lake City was successful because of the close collaborations and interactions between VTMX and CBNP investigators, the contribution (financial, personnel, and/or equipment) of other agencies/companies to the experimental effort, and most importantly, the support of local and state government personnel, and private business and land owners. The CBNP collaborators consisted of five DOE national laboratories (BNL, LBNL, LANL, LLNL and PNNL), NOAA's Air Resources Laboratory – Field Research Division, DoD's Dugway Proving Ground, the Army Research Laboratory, the British Defense and Evaluation Research Agency, Vaisala Corporation (Helsinki), Coherent Technologies, Inc. (Denver), and Litton Data Systems (Virginia).

Future Outlook

The data from the October 2000 Salt Lake City experiments (VTMX/URBAN1) will be processed and provided to modelers during FY'01 to begin evaluating and testing the dispersion models. Also during FY'01 analysis of the VTMX/URBAN1 data and planning for the major URBAN2 field campaign will begin. Results from VTMX/URBAN1 will be published and the URBAN2 field experiments will be conducted during FY'02. During the later part of FY'02 and into FY'03, the data from URBAN2 will be processed and provided to the modelers for model evaluation. Analysis of URBAN2 will proceed during FY'03 with the results published during FY'04.

The VTMX/URBAN1 meteorological/tracer field experiments investigated complex night-time stable flows during light wind speed conditions. The URBAN2 field experiments will be designed to investigate conditions of dispersion during moderate to high wind speeds, and neutral to unstable atmospheric conditions (daytime). The combination of data from the already completed VTMX/URBAN1 field experiments and the planned URBAN2 field experiments will allow the suite of CBNP dispersion models to be evaluated over a broad range of atmospheric conditions. The possibility of including indoor flow/tracer experiments as part of URBAN2 will be considered. Combining indoor and outdoor dispersion experiments during URBAN2 would allow internal and external building dispersion models to be evaluated in a coupled fashion.

Publications

Shinn, J.H., K.J. Allwine, and G.E. Streit. 2000. "The DOE *URBAN* Field Program for 2000-2004." Paper presented at the Third Symposium on the Urban Environment, August 14-18, 2000, Davis California.

FIGURE CAPTIONS:

1) Salt Lake City, Utah VTMX/URBAN1 study area showing the regional (50 km) and urban (15 km) study domains.

2) Downtown Salt Lake City looking east towards the Wasatch Mountains.

3) SF_6 tracer release location (x) in southeast downtown Salt Lake City looking towards the northwest (direction of plume travel).

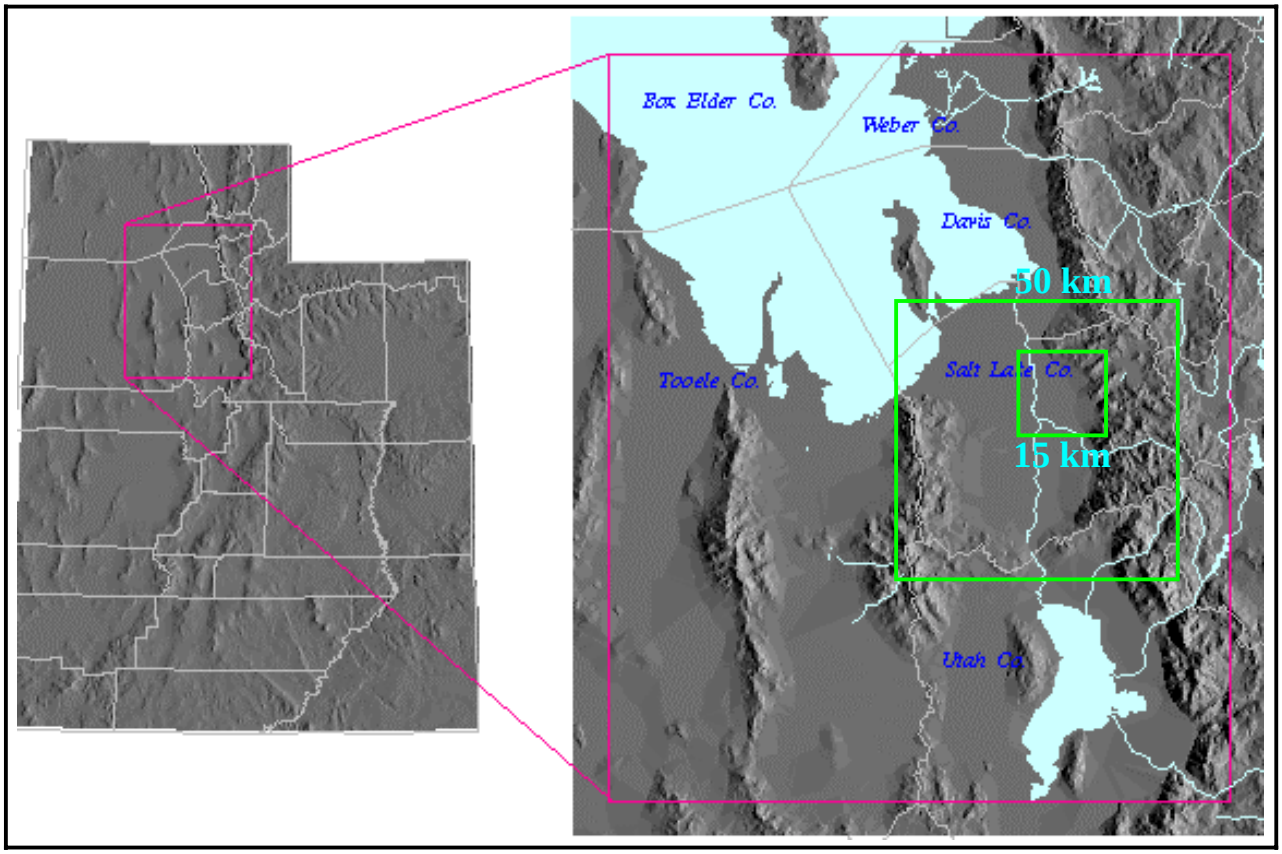

Figure 1

Figure 2

Figure 3